



Commonwealth of Massachusetts

Riverways Programs

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Dear Conference Participant:

Enclosed is a copy of a working paper on **water conservation**. The purpose of this paper is to promote water conservation as a feasible and desirable alternative to further diversions and withdrawals of water from rivers, streams and hydrologically connected surface and groundwater systems. Maintaining an adequate **quantity** of water in rivers and streams is as important to safeguarding their natural integrity as is adequate water quality. In addition, the dewatering of wetlands caused by withdrawals or diversions can be as harmful to the water-dependent organisms located there as the more conventional forms of wetlands alteration.

We seek to change a persistent pattern in this state and elsewhere of escalating and often unrestrained demands for water use typically leading to increasing proposals for additional withdrawals and/or diversions. Such withdrawals and diversions often result in decreased volumes and disruption of natural flow patterns in rivers and streams, key elements of their natural integrity. This problem is further aggravated by the fact that new diversions or withdrawal points are often proposed to be located within the shrinking inventory of relatively unspoiled and uncontaminated areas which possess high ecological values and sensitivities.

We seek to revise this scenario by promoting a statewide policy that encourages all feasible means of conserving water be explored and implemented **before** additional withdrawals or diversions are considered. It is our belief that water suppliers, communities and individual consumers that make full use of the water conservation techniques described in this paper and elsewhere would **eliminate** the need for additional withdrawals and/or diversions for the foreseeable future and perhaps indefinitely. We also believe that increased water conservation would enable a cutback in **existing** withdrawals and facilitate the **restoration** of rivers and streams where ongoing or previous withdrawals have caused significant degradation.

Please contact us if you would like additional copies of this working paper (we currently have a limited number of copies available). You are also welcome to cite this paper or copy it in whole or in part. We are also exploring the possibility of having this paper published in order to give it wider distribution. The projected audience for this paper includes water suppliers, state agencies, local officials, conservation commissioners, and anyone concerned with protecting the natural integrity of rivers, streams and wetlands. If you have any ideas in this regard, please let us know.

Last but not least, we would like to encourage you to contact our office with additional information on successful water conservation techniques and programs and/or the environmental impacts of water withdrawals on rivers, streams and wetlands as well as citations of relevant books, articles, etc. We may be able to incorporate them in an updated version of this paper.

Thanks.

Sincerely yours,

Russell A. Cohen
for Riverways

Enclosure

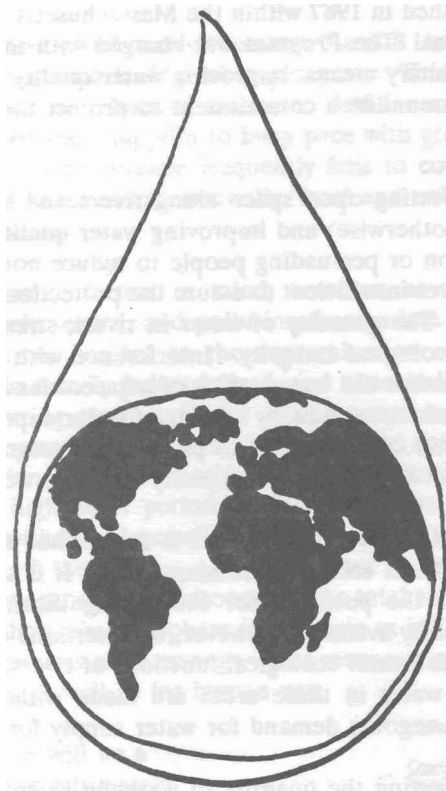
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An Agency of the Department of Fisheries, Wildlife & Environmental Law Enforcement

John C. Phillips, *Commissioner*

CONSERVATION WORKS:

The Ecological and Economic Benefits of Conserving Water.



Summer, 1990

A Working Paper

prepared by Judith J. Wagner and Russell A. Cohen
for the

Massachusetts Riverways Program

Department of Fisheries, Wildlife and Environmental Law Enforcement

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I. INTRODUCTION -- WATER QUANTITY AFFECTS NATURAL INTEGRITY.

The Riverways Program was established in 1987 within the Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement. The Program was charged with the task of protecting the rivers of the Commonwealth through two primary means: improving water quality and conserving open lands along rivers. Together these two goals amount to a commitment to protect the natural integrity of rivers, their tributaries and adjacent lands.

It soon became apparent that protecting open space along rivers and streams (through purchase, town bylaws, conservation restrictions or otherwise) and improving water quality (by enforcing and/or tightening permits for point sources of pollution or persuading people to reduce non-point sources of contamination, for example) were in and of themselves insufficient to assure the protection of our river and stream corridors as healthy, functioning ecosystems. The quantity of water in rivers, streams and hydrologically connected areas is also a critical element of ecological integrity. Interference with naturally-occurring flow volumes and patterns in rivers and streams and/or the water tables of adjacent lands can cause serious disruption of habitat, threatening the continued existence of many species of water-dependent plants and animals. Thus, the Riverways Program, in furtherance of its mission to protect the natural integrity of rivers, streams and adjacent lands, necessarily became involved in water quantity issues as well.

Water withdrawals in situations where a quantity of water is determined to be hydrologically "available" or "safe" may nevertheless trigger significant ecological consequences. It is safe to say that any withdrawal of water above a nominal amount has the potential for causing significant environmental damage. Little sound scientific information is currently available, however, to determine exactly when or how a current or proposed withdrawal affects the fundamental ecological functions of rivers, streams and adjacent lands. Yet decisions affecting the quantity of water in these areas are made without specific knowledge regarding impacts, driven in large part by the ongoing demand for water supply for a variety of human uses.

Recommendations and decisions affecting the quantity of water in rivers and streams are currently being made by a number of state agencies, including the Department of Environmental Management (through its river basin planning process), the Department of Environmental Protection (through its administration of the Water Management Act and other water supply programs) and the Executive Office of Environmental Affairs through its Water Resources Commission (which administers the Interbasin Transfer Act and sets state water policy). Many decisions in the past have been made primarily on the basis of human demand rather than environmental concerns. There is a crucial issue to consider, however, before recommendations and decisions are made which call for water to be withdrawn from rivers, streams and/or hydrologically connected areas for human use. At what point does the continued and/or additional withdrawal of water from the natural environment pose a significant threat to the natural integrity of rivers, streams and other wetlands?

Further research is clearly needed to provide us with more specific information for identifying and safeguarding the particular flow volumes and patterns of rivers and streams that are needed to maintain their natural integrity. Fortunately, there is a feasible solution to the seemingly irreconcilable conflict between keeping ecosystems alive and satisfying human needs for water. The solution to the conflict lies in water conservation, both in improving the efficiency of water use and in reducing the demand for water in the first place. Successful water conservation initiatives will result in reducing the necessity for water withdrawals, enabling more water to remain in the natural environment to keep wetlands wet and to maintain naturally-

occurring flow volumes and patterns in our rivers and streams. Effective water-conserving actions and programs will also help to significantly lessen the likelihood of water demand exceeding the available supply. Water conservation reduces the pressure for more withdrawals, providing us with valuable breathing space during which scientific studies determining the necessary water levels for natural integrity can be undertaken. Thus, before we begin the examination of the hydrological and ecological suitability of withdrawing yet more water from the natural environment, we should be asking the following questions: "Why are we using so much water?" and "What can be done to reduce the amount of water being used by consumers?" The information contained in this working paper provides documentation of the significant achievements in water conservation that have already occurred as well as the potential for additional substantial reductions in use.

II. WHY CONSIDER CONSERVATION -- ISN'T MASSACHUSETTS WATER RICH?

Compared to Arizona or New Mexico, which receive between 7 and 8 inches of rain per year, Massachusetts has an abundance of precipitation at nearly 44 inches per year. This fact might seem to indicate that Massachusetts has plenty of water, even "excess" water, to fulfill current and future demands. Water suppliers have traditionally expanded their supplies to keep pace with growing demand while keeping water rates low (so low, in fact that generated revenue frequently fails to cover the suppliers' expenses). This reinforces consumer perceptions of water as an essentially "free" and unlimited commodity, for which there is little need for moderation in use.

It is important to keep several other factors in mind, however, as water use policy and practice are developed. Massachusetts is densely settled, and pollution from urban runoff, combined sewer overflows, municipal landfills and other sources has led to the contamination of much of the state's surface and groundwater. Massachusetts is also heavily industrialized, and historically many of the industries used (and abused) rivers and streams, rendering them unfit for public water supply without expensive treatment. Most importantly, the natural ecosystems of the state--the plant and animal communities--have evolved for thousands of years or more in reliance on the state's relative abundance of water. Many species of plants and fish, for instance, depend on high water periods to flush the stream bottoms or dampen the wetlands where they live. To continually withdraw "excess" water from the natural environment is to place major stress on the ecological systems of the state. Although water is in constant movement (evaporation, precipitation, streamflow, etc.) throughout our environment, the total amount of water is finite. The amount of water currently present within the global biosphere is the same as in the past and all we are likely to have to sustain us in the future. This requires us to manage water resources carefully to ensure adequate supplies for healthy functioning ecosystems as well as for human use.

If water use continues to rise, there will be a demand to increase withdrawals and, ultimately, to develop new water sources. Each new withdrawal has the potential of diminishing the capability of ecosystems to survive. The options for meeting human needs appear differently, however, if the importance of the natural ecosystem is given substantial weight in the decision-making process.

Water Use in Selected Countries

Country	Per capita use (in 1000 liters)
United States	7.2
Canada	4.8
Soviet Union	3.6
Japan	2.6
Mexico	2.0
India	1.5
United Kingdom	1.4
Poland	1.3
China	1.2
Indonesia	0.7

Source: Compendium, p. 58

A Corps of Engineers study entitled The Role of Conservation in Water Supply Planning (April, 1979) lists six reasons that conservation has become important:

First, new reservoir sites have become increasingly scarce. Second, concern for environmental quality has grown. Third, ground water resources are increasingly inadequate to meet the demands of urban areas. Fourth, political, economic and institutional problems of interbasin transfers have proliferated; today it is nearly impossible to plan for transfer of water from one basin to another. Fifth, the costs of water resource development have risen enormously in the last decade as a result of the increase in the price of energy, the increase in the cost of money, and the rise in water quality standards as manifested in the passage of federal legislation...[and] Finally, the demand for urban water has continued to increase.

A recent issue of the Journal of the American Water Works Association (May, 1990) was devoted primarily to water conservation. One of the lead articles states that "...the time is past when [water] needs can be met simply by building more water storage and delivery systems. Today's political, environmental and economic climate makes reliance on structural solutions with no consideration of demand management virtually impossible" (Maddaus, p.12).

Evidence shows that water conservation by suppliers and users of all types -- residential, business, industry and institutional --can help realize a wide range of direct benefits. These benefits include:

- **reduced stress on water supplies;**
- **reduced or stable costs for users over time;**
 - reduced management costs for water suppliers;**
- **reduced overall consumption, thus allowing a margin for growth;**
- **a reduction of wastewater needing treatment and as a result, a short-term or even indefinite delay in the need for large capital expenditures to expand treatment facilities;**
- **improved efficiency of wastewater treatment due to reduced wastewater flow, with resulting reduction in pollution from treatment plants and migration from septic tank leach fields;**
- **reduced demand that eliminates or postpones the need to develop costly and/or environmentally damaging new sources of water supply;**
- **protection of natural systems, increased health of local ecosystems, and increased opportunities for human enjoyment of natural resources such as rivers and streams.**
- **increased recreational opportunities based on healthier fisheries, expanded canoeing and swimming opportunities, thus adding recreation dollars to local economies.**

These benefits are discussed in further detail below.

III. OPTIONS FOR CONSERVING SOURCES AND REDUCING USE OF WATER.

Perhaps because of our seemingly abundant rainfall, New England is in some ways ten years behind many national and west coast efforts to maximize water conservation. A variety of cases collected in the late seventies and early eighties confirm that there are many options for significant water conservation. For example, a recent conservation campaign initiated by California's East Bay Municipal Utility District in response to several consecutive years of below-average precipitation achieved reduction in consumption during the summers of 1988 and 1989 of 30 and 27 percent, respectively, compared with the targeted savings of 25 and 15 percent for these periods (Gilbert, et al., p. 34). The techniques used in this instance were mandatory conservation goals by customer group, strict ordinances on water use, an inclining (increasing) block rate structure and an extensive public relations program. But unless there is public support for such programs, led or at least supported by public policies encouraging water conservation, change can be slow. One article notes:

"In the last several years, the power and natural gas utilities, as well as the suppliers of petroleum fuels, have shed some of their wrinkles and have moved actively, nationally, to the side of conservation. The water-supply field has not made such a quick adjustment" (Brigham, p. 57).

It makes economic and ecological sense to use **risk management** instead of **crisis management** as the approach to water issues. Risk management should be based upon a definition of "safe yield" of water systems which encompasses both human and ecosystem considerations. A useful definition is: "the amount of naturally occurring ground [or surface] water that can be withdrawn from an aquifer [or other water system] on a sustained basis, economically and legally, without impairing the native ground- [or surface] water quality or creating an undesirable effect such as environmental damage" (Fetter, p.450).

There are two major approaches to saving water: **SUPPLY MANAGEMENT** and **DEMAND MANAGEMENT**. Under each of these there are a number of specific options, both physical or technical and administrative or regulatory.

SUPPLY MANAGEMENT OPTIONS

To preserve the existing supply of water, a number of techniques have proven useful:

- leak detection
- metering (also a demand management tool)
- pressure reduction
- watershed and aquifer protection

LEAK DETECTION programs can discover losses to water distribution systems amounting to as much as 50% of a system's total water supply. A cautious estimate is 20 to 30%. Checks for broken pipes, faulty valves or other structural problems and a maintenance program can produce impressive results. In one year the town of Arlington, MA, located 26 leaks, repaired them for a cost of \$4,300 and saved 250 million gallons of water worth \$61,200 (Before the Well Runs Dry, Volume 1, p. 44.). In 3 years, the Massachusetts Water Resources Authority located leaks totalling 30 million gallons per day throughout its own and associated distribution systems. Thanks in large part to a leak detection initiative by the Water and Sewer Commission, Boston's average daily water use dropped by 39 million gallons (26%) over the past ten years. Water suppliers should survey their systems for leaks at least twice per year, and any leaks discovered should be fixed as soon as possible.

METERING should go hand in hand with leak detection. Accurate metering resulted in a reduction of water use from 13% to 45% in a series of studies running from 1946 to 1983. (Compendium, Table 7-3, p. 191.) Outdoor watering, in particular, experienced the greatest reductions. The metering of public facilities, including schools, town offices, and perhaps even fire hydrants should be considered as a means of monitoring and reducing unnecessary water use. Communities should establish an ongoing program of periodic meter testing, repair and/or replacement.

Both leak detection and metering are important tools for reducing the unaccounted for water in a distribution system. Water suppliers with significant amounts of unaccounted for water (over 10%) should be required to reduce that amount before proposals to expand existing sources and/or withdrawal rates are considered.

PRESSURE REDUCTION can also be effective, particularly in conjunction with leak repairs and meters. Savings run from 3% to nearly 10% in various studies. (Compendium, Table 7-4, p. 193.) In general, reducing pressure from 100 pounds per square inch (psi) to 50 psi results in a decrease of flow at the tap of one-third. Pressure over 80 psi can be considered excessive. An added benefit is that reduced pressure reduces wear and tear on pipes, fixtures and appliances.

RESOURCE PROTECTION can improve flows and recharge of the water source as well as protecting supplies from contamination, thus reducing the need for establishing new withdrawal points within the shrinking inventory of watersheds and/or aquifers that remain relatively unspoiled (which, not surprisingly, tend to be those areas with the highest ecological values and sensitivities). Massachusetts' open space acquisition programs, aquifer land acquisition program, and local efforts to set aside water resource lands are good examples of what needs to be done. Unfortunately, many of these efforts are now seriously diminished by lack of state and local funds. A relatively low-cost alternative to acquisition is the adoption of local watershed and/or aquifer protection bylaws which seek to restrict potentially contaminating land uses within water supply areas. Board of Health regulations can also be used to limit underground storage tanks, nitrogen loading and other potentially degrading activities. A number of Massachusetts communities (Blackstone, Auburn and Falmouth, for example) have successfully implemented such measures, but many more communities have yet to recognize their value and take positive action to protect threatened areas. The payback period for the physical improvements to reduce water loss is very short and often dramatic. Funds to implement these techniques can readily be obtained through true cost pricing and/or enterprise accounts (see below).

DEMAND MANAGEMENT OPTIONS

A tremendous amount of water can be saved with the cooperation of users. There are a wide range of techniques to enlist this cooperation, including:

- consumer education and information
- water-saving devices
- regulation or use restrictions
- price changes
- enterprise accounts
- water-saving landscaping techniques
- water emergency declarations

EDUCATION can convince users of the need to change their habits and to take advantage of water saving devices as well as complying with short or long term restrictions. Media, printed information, local meetings, and work with schools and other community institutions can reach people effectively. Water suppliers should provide information to their customers on water conservation tips at least once per year. Some small changes in behavior can have large effects on water use:

Personal Water Conservation		
Activity	Normal Use/Quantity	Conservation Use/Quantity
Toothbrushing	Tap running, 10 gallons	Wet brush, rinse, .5 gallons
Shaving	Tap running, 20 gallons	Fill basin, 1 gallon
Tub bath	Full bath, 36 gallons	Minimum water level, 10-12 gallons
Shower	Water Running, 25 gallons	Wet down, soap, rinse, 4 gallons
Dishwashing	Tap running, 30 gallons	Wash & rinse in pan or sink, 5 gal.
Automatic Dishwasher	Full cycle, 16 gallons	Short cycle, 7 gallons

Communities should also educate their employees (office workers and janitors as well as water and sewer department employees) about the values of water conservation, and provide rewards or other incentives for employees who initiate successful water-saving actions.

WATER SAVING DEVICES for homes and businesses can make a dramatic difference in water use. A household installing a 1.6 gallon flush toilet in Boston would not only save between \$39 and \$108 in 1989 water charges, but would also save 11,680 to 32,120 gallons per year (Compendium, p. 210). A study for the U.S. Department of Housing and Urban Development showed that the payback for installing domestic water-saving devices ranged from 9 weeks for showerheads to 47 weeks for toilet dams, in all cases less than one year (Brown and Caldwell, 1984). Research on demand modification shows that 50% of the water used for showers and baths could be saved, 30% of the water used for laundry and 40% of the water used for the toilet could be saved with technology available in 1980. (These savings do not include any newer water-saving appliances which are slowly becoming available.) The same study estimates that a 30 percent reduction of water use is feasible in the commercial sector (Kim & McCuen). One General Electric facility in Massachusetts accomplished a 28% reduction in water use simply by asking guards to check water waste on weekends only. Many engineering options are now available to help commercial, industrial and institutional establishments conserve water through reuse or recycling, closed internal water systems or changes in processes. The Robbins Company in Attleboro, MA, switched to a closed loop water system and reduced its water use by 95%. Industrial reuse of water has been steadily increasing for the past 20 years. It is estimated that expected savings from industrial reuse will double between 1985 and the year 2000. (Compendium, p. 214.)

REGULATION OR USE RESTRICTIONS can be used to establish mandatory, conservation-driven performance standards relating to water use. Massachusetts has recently amended the Uniform State Plumbing Code to require the use of low-flow toilets in all new construction, for example. The Mass. Water Resources Authority (MWRA) has also requested the Board of Examiners of Plumbers and Gas Fitters to amend the Code to require the reuse of non-contact cooling water (i.e., prohibit once through cooling systems) and mandate the use of water efficient plumbing fixtures in new developments and renovations. Water audits of various business serviced by the MWRA have shown that recirculating cooling water provides the greatest single opportunity for water savings in many businesses.

PRICE CHANGES can be a strong incentive for consumers to reduce water use. **True cost pricing** has received considerable attention of late, but has yet to be implemented on a wide basis in this state or elsewhere. Charging customers what it actually costs to obtain clean, reliable water can be a surprise. With clear leadership, as in the case of the city of Fitchburg, MA, increased prices can be introduced as part of a package of efforts to reduce water consumption. Increased prices also help offset potential reductions in revenue to water suppliers due to decreased demand if conservation works at the rate that it should. At a minimum, water suppliers should eliminate lower prices for large water users (recent legislation in Massachusetts will soon make decreasing block rates unlawful in most situations). Many communities are now instituting increasing block rates, so that any water used above certain levels costs more than the first amount. Higher rates could also be charged during the late summer and other periods of low rainfall as a means of ensuring adequate supplies and reducing the environmental impact of further withdrawals at a time when rivers and streams are already under severe stress.

ENTERPRISE ACCOUNTS are a means of enabling water suppliers to retain revenue received from water sales to directly fund various costs associated with providing a clean and reliable supply of water to their customers. Such accounts need not be limited to funding typical operating expenses; they could also cover the cost of purchasing and distributing water-saving devices, hiring staff to promote conservation and/or monitor water consumption, even purchasing aquifer and/or watershed land.

LANDSCAPING can provide considerable savings, since one of the largest uses of water is outdoor irrigation. Much new information is being developed about ecologically sound approaches to landscaping, using native species, reducing water-intensive areas such as carpet lawns, and using mulches and cultivation techniques such as drip irrigation which reduce water consumption. Shifting the time of watering away from the middle of the day significantly reduces the amount of water lost through evaporation. Automated sprinkler systems can be monitored or equipped with a device that prevents them from operating during or just after a rainstorm. For the home gardener, rain barrels or cisterns as well as species selection and conservation cultivation are effective means of reducing water consumption.

WATER EMERGENCY DECLARATIONS have the potential to substantially reduce water withdrawals and consumption in situations of low water supply such as droughts when natural systems are already under severe stress and have a greatly diminished capacity to yield water for human use without serious ecological repercussions. Section 15 of the Water Management Act enables a public water supplier to petition the Department of Environmental Protection (DEP) to declare a state of water emergency within its service area. The DEP is empowered under this provision to require a wide range of mandatory conservation actions, including:

- partial or total shutoff of service to selected customers;
- bans or restrictions on certain water uses;
- the implementation of water conservation programs for public and private buildings; and
- a moratorium on the issuance of building permits.

The DEP is also empowered by §17 of the Act to order any "person" (interpreted broadly) to reduce water withdrawals by a specified amount or to stop them entirely. The key to using this technique to protect the natural integrity of rivers, streams and associated wetlands is for a water supplier to petition the DEP to declare an emergency before the situation really gets desperate from an ecological standpoint. Towns typically wait until their withdrawals of water reach or exceed the "safe" or "available" yield of their water supply sources; i.e., when it becomes physically impossible to withdraw additional water on a sustainable basis. The problem with this is that water levels may drop to such an extent that wetland and/or riparian ecosystems may be deprived of water at a critical period for the survival of one or more species, even though there is technically still water in the system that is hydrologically "available" or "safe" for withdrawal. Thus, emergencies should be declared and immediate action taken to reduce consumption when natural integrity is threatened (i.e., when the ecological threshold is reached) without waiting until conditions deteriorate further until the hydrological threshold is reached.

When all these approaches are added up or organized into programs for comprehensive water conservation, there are definite and positive cost/benefit ratios. One set of studies indicates a range of benefits to costs from 5:1 to more than 50:1 !

Reducing the overall volume of water used by all consumers means that much less water must go through treatment systems, whether municipal plants or home septic systems. Reducing the volumes can extend the practical life of these facilities, saving considerable capital expenditures. It also reduces the polluting effects of these facilities.

ENERGY SAVINGS are an unexpected bonus to water conservation. It has been estimated that every thousand gallons of water delivered requires 2.6 kilowatt-hours for transportation, treatment, distribution and wastewater treatment. Heating 1000 gallons for domestic or other purposes requires 185 kWh. For a business reducing hundreds of thousands of gallons of water use, or even a household saving a few thousands gallons, these energy savings could add up to a significant additional financial gain. In addition, there are amazing environmental "multiplier" benefits from reducing energy consumption. For every 60-watt bulb replaced with a 15-watt compact fluorescent bulb, for example, 1000 fewer pounds of carbon dioxide and 20 fewer pounds of sulfur dioxide are emitted from a coal-burning power plant.

IV. ECOLOGICAL AND ECONOMIC BENEFITS OF WATER CONSERVATION.

ECOLOGICAL BENEFITS from water conservation include as a primary element the maintenance of natural water flow volumes and patterns in our rivers and streams. This is a key factor in the sustainability of natural riparian communities, which serve as crucial infrastructure for the ecological stability and diversity of the Commonwealth's native plants, animals and associated habitat. Natural communities have many roles in keeping our ecosystem healthy. Certain birds and insects help farmers; soil organisms cleanse water working its way into wells; trees and plants stabilize banks, reduce erosion, provide shade that keeps water temperatures low and cleanse the air and soils; plants and insects in streams feed fish, other aquatic organisms and birds and mammals that favor riparian habitat; and all of these provide visual diversity and appeal which enlivens a landscape for human purposes. Keeping water in our rivers and related wetlands allows them to properly function as critical habitat for aquatic and wetland organisms as well as natural facilities for cleansing impurities and counteracting pollution.

A river and its tributaries operate as a cohesive natural system, a living entity which cannot be severed successfully into a "fish part, a "recreation part," a "water supply" part and so forth. The various functions of a river or stream are deeply interconnected and affect each other; if one is disrupted, other functions will also be affected in ways that are sometimes hard to anticipate. Furthermore, dewatering wetlands through excessive water withdrawals can be as damaging to water-dependent species as any other form of alteration. Once a particular ecosystem is damaged or lost, neighboring ecosystems are affected as animals migrate, flora changes, or hydrology is altered.

The American Fisheries Society (AFS), in a policy statement approved in September, 1989, describes the "impacts of altered stream flows" as follows:

Changes in stream flow can affect fishes directly and indirectly. Direct effects of flow alterations are certainly important if migrations are blocked, fish are trapped in dewatered sections, or reproduction is disrupted. However, insidious effects may be far more detrimental, and include alteration and loss of stream habitat, introduction of competing non-native fishes, degradation of water quality, and other effects. As an example, it is difficult to assess fishery impacts associated with a reduction in stream flooding; however, changed nutrient cycles and disruption of food webs may have serious ecosystem consequences.

Decreased stream flow can contribute to direct mortality if fish eggs are exposed, covered with silt, or left without sufficient oxygenated water. Reduction in usable habitat can result in decreased abundance, size, and condition of fishes. Water velocities and the amount of appropriate substrate can be so changed that spawning sites become limited, and in some species, an increase in interspecific hybridization may occur. Anadromous or resident species may not move to appropriate spawning sites if attractant flows are lost or stream passage is inadequate.

Reduction in spawning or nursery habitats by stream regulation or diversions can concentrate eggs and young, encouraging increased predation by resident or introduced fishes. Production of essential food organisms, or their availability in occupied habitats, may be reduced for all life stages of fishes. Productivity of riverine systems may be reduced by storage projects that trap nutrients or release water at unfavorable [times, volumes or] temperatures. (Tyus, pp. 18.)

Whole, functioning rivers and streams are critical for species diversity beyond fish populations. For example, Massachusetts is part of the great Atlantic flyway for migratory waterfowl and provides a summer home to many birds which are native to rain forests during the winter. Consequently, protecting the natural integrity of the state's riparian corridors has international implications.

The American Fisheries Society further describes the values of estuaries in maintaining diversity of species:

Estuaries are also sensitive to alteration and reduction of stream flow. Eggs and larvae of some estuarine fishes cannot tolerate high salinity of the marine environment that may result from reduced freshwater flows. In this case, the quantity and seasonal timing of freshwater inputs are particularly critical to these sensitive stages. Productivity of estuarine food organisms partially depends on the allochthonous material transported by rivers. Reservoirs may act as nutrient traps thereby reducing estuarine productivity. (Tyus, p. 19.)

The AFS policy statement proceeds to reiterate the necessity for identifying and safeguarding ecologically adequate instream flows, and describes the consequences of further reductions in and/or manipulations to streamflow:

Instream flows are a public trust, and stream ecosystems must be protected as irreplaceable resources. Natural stream systems, if properly managed, can provide sport, subsistence, and commercial fisheries at little cost. However, unless stream flows are established, implemented, and protected, the following impacts can be expected to accelerate:

1. Replacement of unique regional fauna by fishes adapted to the more regulated stream environment. This extirpation will result in more listings of endangered species. Stream fishes currently considered as endangered will continue to disappear in nature.
2. Reductions in localized stream flooding will continue to degrade bottomlands and reduce stream productivity, adversely affecting stream fishes.
3. Riparian habitat will continue to be degraded, and degradation will adversely affect stream quality.
4. Reductions of stream flows will reduce and degrade stream habitat, increase summer water temperatures, reduce oxygen, and concentrate pollutants.
5. Fluctuating flows associated with power generation will reduce stream resources by promoting unstable channels. Such flows will alternately scour, then promote downstream siltation of stream habitats.
6. Loss of spring peak flows below dams will result in perennial armoring of stream bottoms, with downstream effects of wider, shallower channels due to loss of stream power to move sediments. Alteration of natural hydrographs will result in changed species composition. (Tyus, p. 19.)

In addition, healthy flowing streams and rivers provide for a more pleasing overall environment, which affords respite from urbanized sights and sounds and smells and wonderful opportunities for rejuvenation through outdoor experiences. Rivers and their tributaries are the circulatory system for the environment, and keeping them flowing and healthy is crucial to the health of the entire ecosystem.

ECONOMIC BENEFITS of maintaining strong and healthy systems of protected riparian corridors include: reduced health care costs for citizens; the protection of pleasing landscapes, which enhances the state's ability to retain and attract top quality workers and businesses; and providing the basis for a thriving recreational industry, including canoeing, kayaking, freshwater fishing and associated activities, which together generate over \$500 million annually within the Commonwealth. Keeping adequate flows in rivers and streams helps to enhance the value of the boating and/or angling experience. Other important trades such as traditional commercial fishing and lobstering are intimately tied to the health of rivers and estuaries that serve as spawning grounds. An estimated \$70 million in potential harvesting revenue has been lost to the state in recent years due to contamination of shellfish beds by human pollution. Increased water conservation can reduce the amount and concentration of contaminants transported to shellfish beds.

Even from a strictly economic standpoint, **adoption of conservation and demand management measures may turn out to be less expensive than the development of new sources of supply** (see discussion of the MWRA's experience below). All proposals for new wells, reservoirs, must undergo extensive environmental reviews and frequently face considerable political opposition that can add months or even years of delay and cost to any project. Even if these formidable hurdles are cleared, other project-related costs (land purchase, well drilling or reservoir construction, etc.) can be major capital expenditures. Investing the same or even a lesser sum on thoughtful conservation measures can free up an equivalent amount of water to that obtained from developing an additional source. Electric utilities have found this to be true and are now aggressively pushing conservation among their customers. Water suppliers should follow their good example.

V. CAN CONSERVATION WORK IN MASSACHUSETTS?

In the last three years, the Massachusetts Water Resources Authority (MWRA), which is responsible for providing water for 46 cities and towns in eastern and central Massachusetts, has done groundbreaking work on conservation. When two years of below normal rainfall (1988 and 1989), combined with a long-term history of exceeding the yield of Quabbin Reservoir, threatened the MWRA's continued ability to supply its customers, a water emergency was declared and specific restrictions were placed on water use. In addition, the MWRA launched a major public information program and a comprehensive leak detection and repair program which identified and recovered the loss of some 30 million gallons of water. The ensuing reduction in water use within MWRA's service area exceeded expectations (The Case for Conservation, p. 1). Even allowing for the unusual heavy rains that alleviated some of the expected demand during the hottest part of the summer of 1989, water use dropped significantly, by more than 10% (36 million gallons per day). As a result, the most recent **Long Range Water Supply Program Report** for the MWRA states:

"For the first time in 20 years, we are living within our means... These savings have been achieved by the Program at a far lower cost per million gallons than any of the new sources previously considered."

The MWRA Board has decided that the potential for additional conservation is so great that they are postponing decisions about investing in any major new sources of water supply for at least five years. They estimate that if the programs planned by the long range supply program are fully implemented in the next five years, demand will stay below safe yield for at least the next ten years and possibly through the year 2020. The tremendous cooperation by users of the MWRA system, by local water supply officials and others, such as the media which helped explain the situation, indicates the great potential not only in the MWRA service area, but in all the 309 other cities and towns in the Commonwealth. The specific conservation and demand management strategies recommended by the latest MWRA report for the next five years could serve as an excellent blueprint for statewide action. One obstacle to this is the large number of municipal, private and other water suppliers scattered throughout the state; but better coordination, leadership and involvement on the part of existing state programs could help achieve significant results.

By conserving water, citizens are reducing or holding steady their own water bills, reducing costs to local governments for water supply and wastewater treatment, and keeping water in the natural systems, thereby increasing ecological health and productivity. If conservation becomes a priority, then some of the difficult decisions about streamflow protection, water use permits and planning for future water needs become more focused on the whole system, not just on an ill-fated effort to expand supplies to satisfy estimated increasing human demands for water based in large part on past wasteful use patterns. Conservation can ease the potential conflict between human uses and the natural integrity of our ecosystems.

VI. CONCLUSION.

A **Statewide Rivers Policy and Action Plan** was announced by Environmental Affairs Secretary John DeVillars in June of 1989. This Policy has three broad priorities:

- * **No further degradation** of the natural integrity of rivers and streams;
- * **Establish green corridors** along rivers and streams wherever feasible; and
- * **Strengthen the partnership between public and private interests** to protect river and stream systems.

The Action Plan specifically calls for the preparation and implementation of a **statewide water conservation plan** to reduce demands on water supplies. Implementation of the various water-saving and watershed-protecting measures discussed in this working paper is clearly in furtherance of the Statewide Rivers Policy and Action Plan and is a crucial component of a comprehensive and effective river protection effort. This paper is only a beginning, however; additional water conservation techniques and strategies will continue to emerge and should be considered and adopted to take the suggestions of this paper even further.

The Statewide Rivers Policy and Action Plan concludes with the following quotation from the Great Law of the Six Nations Iroquois Confederacy: "We must in our every deliberation consider the effects of our decisions on the next seven generations." If we get serious about water conservation and build it into our lives, we will move closer to the "wise use" of water that will honor future generations and the environment.



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CONSERVATION WORKS:

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